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CLAIMS:

1. A method comprising the steps of:

when a local temperature change takes place in a certain position inside an object, acquiring a measured phase distribution image representing a temperature distribution inside said object using, as a temperature indicator, a phase of complex magnetic resonance signals from water protons inside said object observed by a magnetic resonance tomographic imaging technique;

defining a certain position in said acquired measured phase distribution image as a region of interest;

estimating a phase distribution of complex magnetic resonance signals before a temperature change in said region of interest based on a phase distribution of complex magnetic resonance signals in a portion surrounding said region of interest;

acquiring an estimated phase distribution image based on said estimated phase distribution;

calculating an amount of phase variation of complex magnetic resonance signals caused by a temperature change in said region of interest by conducting subtraction between said measured phase distribution image and said estimated phase distribution image on a pixel-by-pixel basis; and

measuring an amount of a temperature change in said region of interest based on said amount of variation.

2. A method comprising the steps of:

when a local temperature change takes place in a certain position inside an object, acquiring a real-part image and an imaginary-part image as measured complex images incorporating a temperature distribution inside said object using, as a

temperature indicator, a phase of complex magnetic resonance signals from water protons inside said object observed by a magnetic resonance tomographic imaging technique;

defining the same position in said acquired real-part and imaginary-part images as a region of interest;

estimating a distribution of a real part and an imaginary part of complex magnetic resonance signals before a temperature change in said region of interest based on a distribution of a real part and an imaginary part of complex magnetic resonance signals in a portion surrounding said region of interest;

acquiring an estimated complex image based on said estimated real-part and imaginary-part distribution;

calculating an amount of phase variation of complex magnetic resonance signals caused by a temperature change in said region of interest by calculating a phase difference between said measured complex image and said estimated complex image on a pixel-by-pixel basis; and

measuring an amount of a temperature change in said region of interest based on said amount of variation.

3. The method as defined by claim 1, characterized in comprising: estimating a phase distribution of complex magnetic resonance signals in a region of interest by applying higher-order rational polynomial fitting by a linear least squares method, functional fitting by a non-linear least squares method, or a finite element method to a phase distribution of complex magnetic resonance signals in a portion surrounding said region of interest.

4. The method as defined by claim 2, characterized in comprising: estimating a distribution of a real part and an imaginary part of complex magnetic resonance signals in a region of interest by applying higher-order rational

polynomial fitting by a linear least squares method, functional fitting by a non-linear least squares method, or a finite element method to a distribution of a real part and an imaginary part of complex magnetic resonance signals in a portion surrounding said region of interest.

5. The method as defined by claim 1 or 3, characterized in comprising: conducting subtraction between a measured phase distribution image and an estimated phase distribution image on a pixel-by-pixel basis by multiplying complex conjugates of complex numbers of complex magnetic resonance signals with each other and calculating an arctangent of the product.

6. The method as defined by claim 2 or 4, characterized in comprising: calculating a phase difference between a measured complex image and an estimated complex image on a pixel-by-pixel basis by multiplying complex conjugates of complex numbers of complex magnetic resonance signals with each other and calculating an arctangent of a ratio between a real part and an imaginary part of the product.

7. The method as defined by any one of claims 1 — 6, characterized in comprising: outputting a distribution image of the amount of a temperature change based on the amount of phase variation of complex magnetic resonance signals superimposed over an anatomical image of organ or tissue acquired by a magnetic resonance tomographic imaging technique.

8. The method as defined by any one of claims 1 — 7, characterized in comprising: capturing a phase distribution image of complex magnetic resonance signals in one, two or three orthogonal planes intersecting an extension of an in-body penetrating portion of a heating or cooling apparatus during thermo-treatment or cryo-treatment so as to include a tip of said in-body penetrating portion, or in two or more parallel planes.

9. The method as defined by claim 8, characterized in comprising:

checking the position of the tip of the in-body penetrating portion of the heating or cooling apparatus using an optical positioning apparatus, and capturing a phase distribution image of complex magnetic resonance signals so as to include said tip.

10. The method as defined by claim 9, characterized in comprising: providing a marker at the tip of said in-body penetrating portion, and checking a position of the tip of said in-body penetrating portion by detecting said marker in an MRI image or numerically detecting it.

11. The method as defined by claim 10, wherein: the method of providing the marker comprises providing the tip of said in-body penetrating portion with inductor elements or applying a contrast agent to the tip of said in-body penetrating portion.

12. The method as defined by any one of claims 8 — 11, characterized in comprising: when target organ or tissue moves with body motion, capturing a phase image of complex magnetic resonance signals following the movement or covering a range of the movement.

13. A temperature change measurement apparatus comprising:

means of, when a local temperature change takes place in a certain position inside an object, producing a measured phase distribution image representing a temperature distribution of said object using, as a temperature indicator, a phase of complex magnetic resonance signals from water protons inside said object observed by a magnetic resonance tomographic imaging technique;

means of defining a region of interest in said acquired measured phase distribution image;

means of estimating a phase distribution of complex magnetic resonance signals before a temperature change in said region of interest based on a phase distribution of complex magnetic resonance signals in a portion surrounding

said region of interest;

means of producing an estimated phase distribution image based on said estimated phase distribution;

means of producing a phase difference distribution image from a phase difference in complex magnetic resonance signals caused by a temperature change in said region of interest by conducting subtraction between said measured phase distribution image and said estimated phase distribution image on a pixel-by-pixel basis; and

means of calculating a temperature change from said phase difference distribution image.

14. A temperature change measurement apparatus comprising:

means of, when a local temperature change takes place in a certain position inside an object, producing a real-part image and an imaginary-part image as measured complex images incorporating a temperature distribution of said object using, as a temperature indicator, a phase of complex magnetic resonance signals from water protons inside said object observed by a magnetic resonance tomographic imaging technique;

means of defining a region of interest in said acquired measured complex image;

means of estimating a complex image before a temperature change in said region of interest based on a distribution of a real part and an imaginary part of complex magnetic resonance signals in a portion surrounding said region of interest;

means of producing an image representing the amount of phase variation of complex magnetic resonance signals caused by a temperature change in said region of interest by calculating a phase difference between said measured

complex image and said estimated complex image on a pixel-by-pixel basis; and

means of calculating a temperature change from said phase distribution image.

15. The apparatus as defined by claim 13, characterized in that: said means of estimating a phase distribution applies higher-order rational polynomial fitting by a linear least squares method, functional fitting by a non-linear least squares method, or a finite element method to a phase distribution of complex magnetic resonance signals in a portion surrounding said region of interest.

16. The apparatus as defined by claim 14, characterized in that: said means of estimating a phase distribution applies higher-order rational polynomial fitting by a linear least squares method, functional fitting by a non-linear least squares method, or a finite element method to a distribution of a real part and an imaginary part of complex magnetic resonance signals in a portion surrounding said region of interest.

17. The apparatus as defined by claim 13 or 15, characterized in that: said means of producing a phase difference distribution image conducts subtraction between a measured phase distribution image and an estimated phase distribution image on a pixel-by-pixel basis by multiplying complex conjugates of complex numbers of complex magnetic resonance signals with each other and calculating an arctangent of the product.

18. The apparatus as defined by claim 14 or 16, characterized in that: said means of producing a phase difference distribution image calculates a phase difference between a measured complex image and an estimated complex image on a pixel-by-pixel basis by multiplying complex conjugates of complex numbers of complex magnetic resonance signals with each other and calculating an arctangent of the ratio between a real part and an imaginary part of the product.

19. The apparatus as defined by any one of claims 13 — 18, characterized in comprising: in addition to said means of producing a phase difference distribution image representing the amount of phase variation of complex magnetic resonance signals caused by a temperature change in a region of interest,

means of outputting a temperature image calculated from said phase difference distribution image superimposed over an anatomical image of organ or tissue.

20. The apparatus as defined by any one of claims 13 — 19, characterized in comprising: to capture a measured phase distribution image or measured complex image, means of checking a tip of an in-body penetrating portion of a heating or cooling apparatus, and capturing a phase distribution image or a complex image of complex magnetic resonance signals in one, two or three orthogonal planes intersecting an extension of the in-body penetrating portion of the heating or cooling apparatus, or in two or more parallel planes.

21. The apparatus as defined by claim 20, characterized in that: a position of the tip of the in-body penetrating portion of the heating or cooling apparatus is checked using an optical positioning apparatus.

22. The apparatus as defined by claim 21, characterized in that: a marker is provided at the tip of said in-body penetrating portion, and the position of the tip of said in-body penetrating portion is further checked by detecting said marker by an MRI apparatus.

23. The apparatus as defined by claim 22, characterized in that: said means of providing a marker provides the tip of said in-body penetrating portion with inductor elements or applies a contrast agent to the tip of said in-body penetrating portion.

24. The apparatus as defined by any one of claims 21 — 23, characterized in that: when target organ or tissue moves with body motion, the position of the tip of the in-body penetrating portion of the heating or cooling apparatus is checked following the movement or covering a range of the movement.